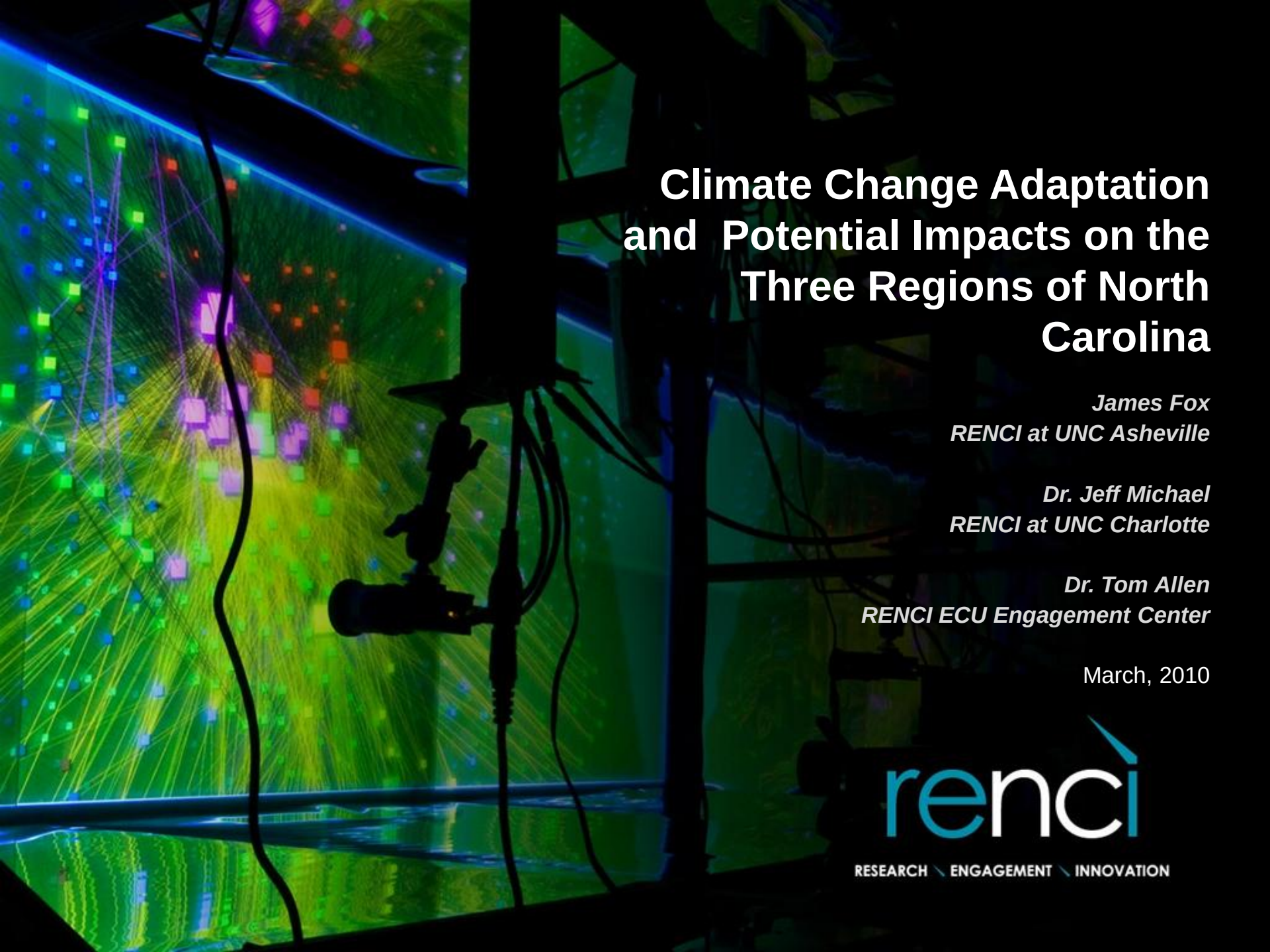


Climate Change Adaptation and Potential Impacts on the Three Regions of North Carolina

James Fox
RENCI at UNC Asheville

Dr. Jeff Michael
RENCI at UNC Charlotte

Dr. Tom Allen
RENCI ECU Engagement Center

March, 2010

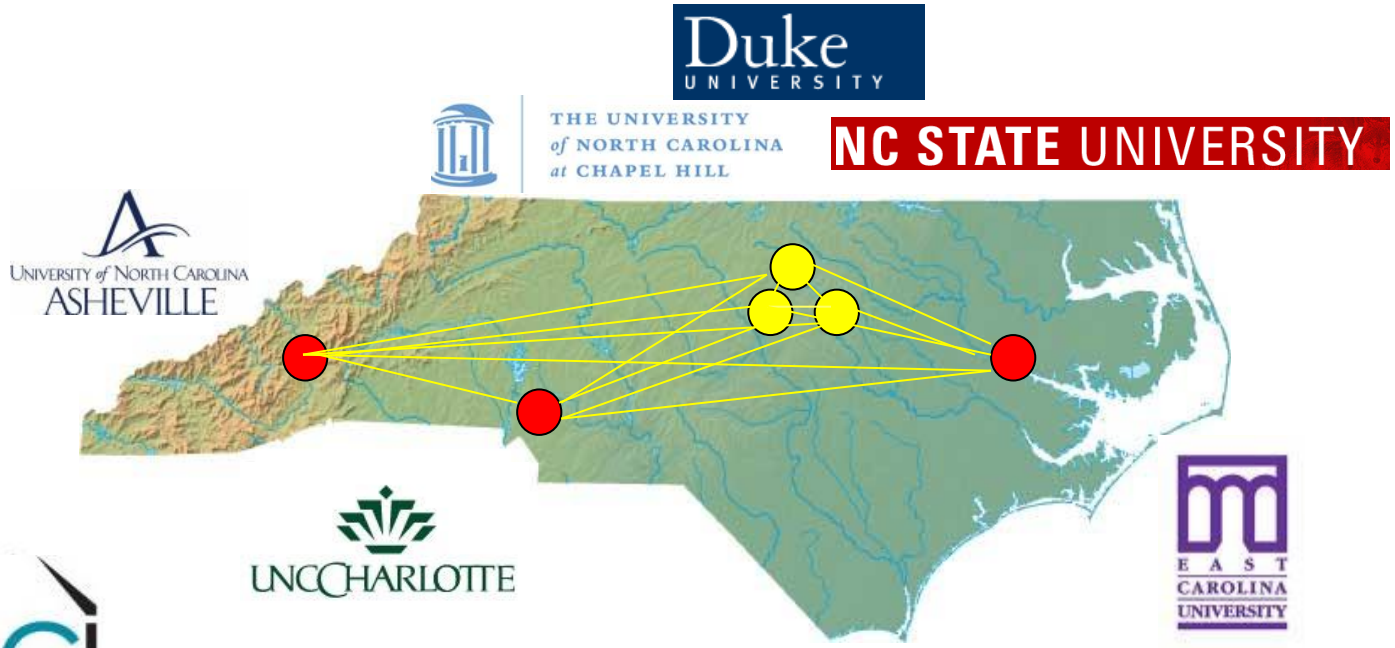
renci

RESEARCH \ ENGAGEMENT \ INNOVATION

What Is RENCI?

- **RENaissance Computing Institute**

–Multi-disciplinary experts, advanced technology
–Multi-institutional model: 6 collaborating universities
–Finding solutions to complex problems affecting our lives
–Migrating the technology off campus and into people's hands



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Our society will not make decisions based solely on Climate Change

- People must be able to integrate Climate Change information with other value drivers
- They must trust the source of information
- Adaptation must accompany mitigation

- These presentations raise issues for discussion at break-outs after lunch

Water Resources

Development Pressure

Escalating Energy Costs

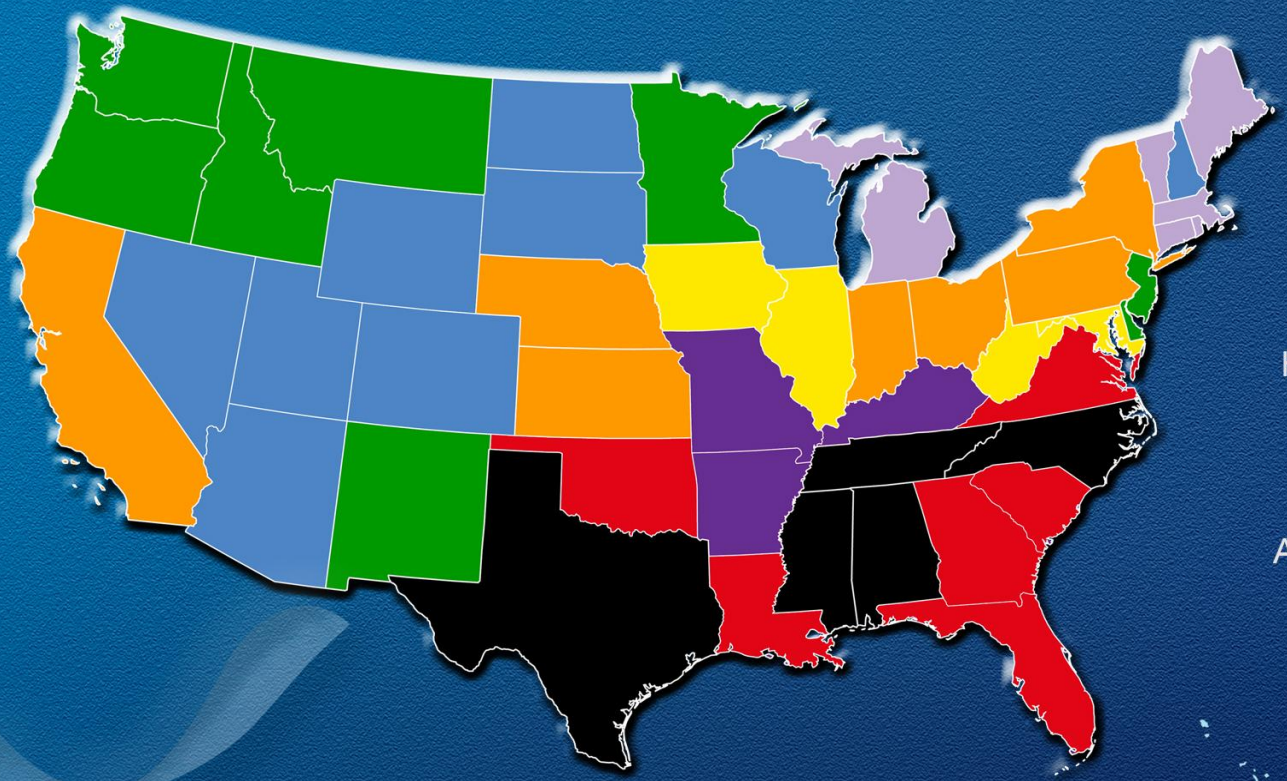
Focus on VALUE

- As part of a community, we rely on a set of **services** and we are willing to pay for those services – through taxes, cost of living, etc.
- Those services may be **stressed** by a variety of things – but we can usually plan based on trends, etc.
- Services that are **interrupted** are harder to deal with
- There are differences in **Natural Services** and **Infrastructure Services**, especially when we look at **vulnerable populations** (which could be human or ecosystem based)
- How do we look at these from a value perspective?

BILLION DOLLAR CLIMATE and WEATHER DISASTERS

http://www.ncdc.noaa.gov/img/reports/billion/state2009.pdf

1980 - 2009*



Puerto Rico - 3

U.S. Virgin Islands - 2

Hawaii - 1

not to scale

Alaska - 3

NUMBER OF EVENTS

31 - 35	26 - 30	21 - 25	16 - 20	13 - 15	10 - 12	7 - 9	4 - 6	1 - 3

Regional Approach

- Mountains
  - Water resources and climate variability
  - Vulnerability and Emergency Response
  - Ecosystem Services
- Piedmont
  - Urban societal issues and growth, land use change
  - Water and Power
  - Transportation
- Coastal Plain
  - Sea Level Rise and Storm Surge
  - Agriculture
  - Coastal population patterns, protection, and retreat

Climate Change Adaptation and Potential Impact s on the Mountain Region of Western North Carolina

renci AT UNC ASHEVILLE

University of North Carolina ASHEVILLE

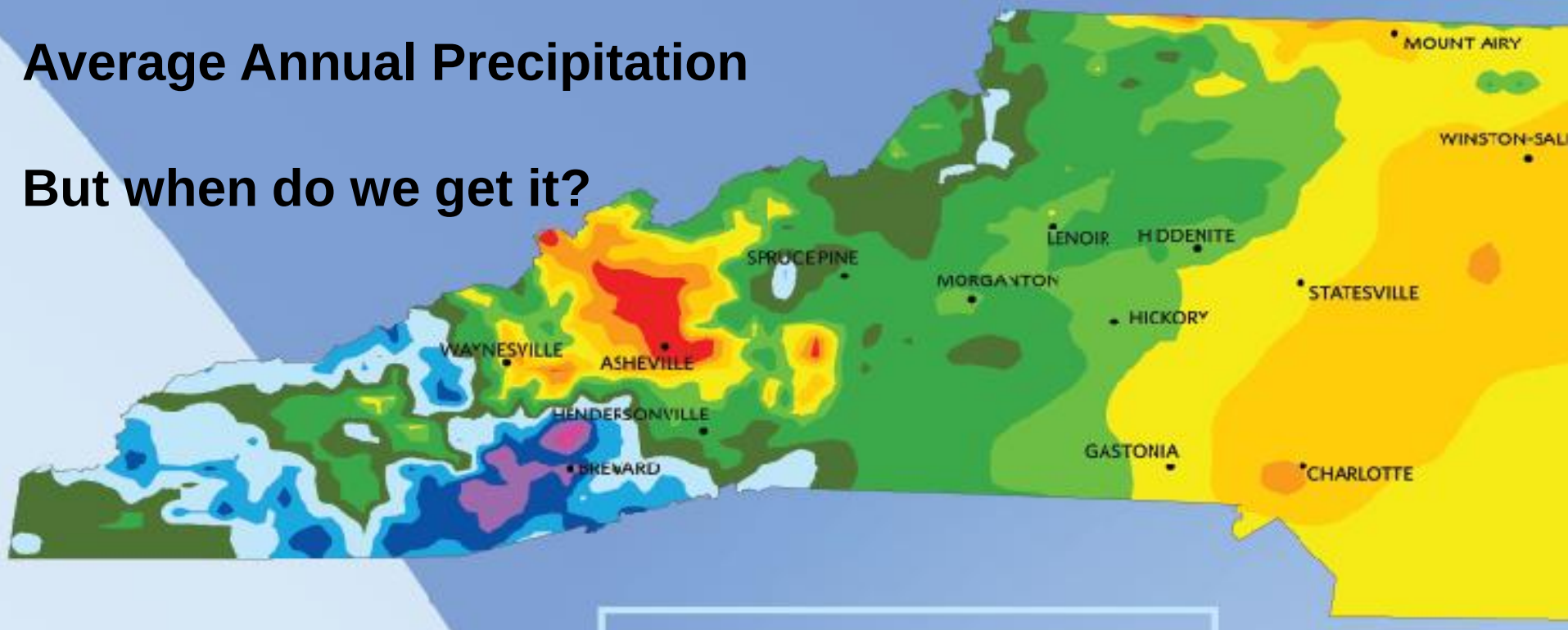
Impacts of Climate Change on North Carolina

Mountain Region

	Long Term Change	Climate Variability
Natural Systems		
Infrastructure		

Average Annual Precipitation

But when do we get it?



Legend (*in inches*)

under 42	56 to 62
42 to 44	62 to 72
44 to 46	72 to 82
46 to 48	82 to 92
48 to 50	92 to 104
50 to 56	above 104

The wettest and driest points in North Carolina are separated by 45 miles!

Feast or Famine

- Drought will be more frequent
- When we get rain, it is likely to be more extreme

**To compound the problem, in the mountains we lack deep, continuous aquifers and therefore have a limited groundwater supply*

Dealing with Climate Variability, Drought and Storms

- Increase in number of events
- Increase in severity
  - Drought, increasing risk tied to wildfires
  - Heavy rains cause flooding, but also instigate landslides
- Additive with other drivers
  - Emergency management
  - At risk populations
- Examples
  - 2004 Hurricanes and resultant flooding
  - Vulnerability of transportation corridors
  - Gulf Coast Storms and the gasoline shortage in Asheville

Flooding in Asheville, 2004 Hurricanes

Dealing with vulnerability – Buncombe County Multi-hazard Risk Tool

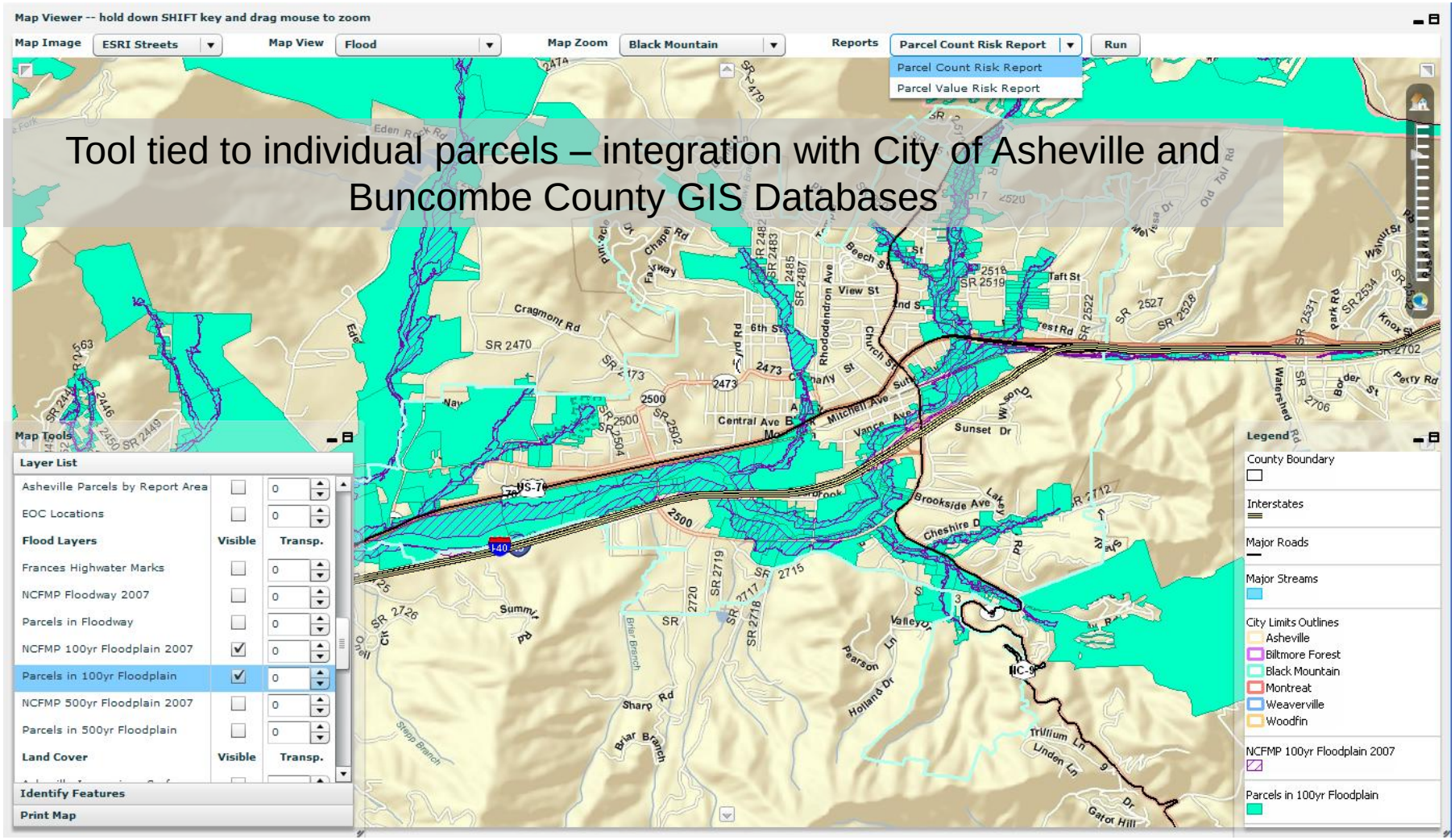
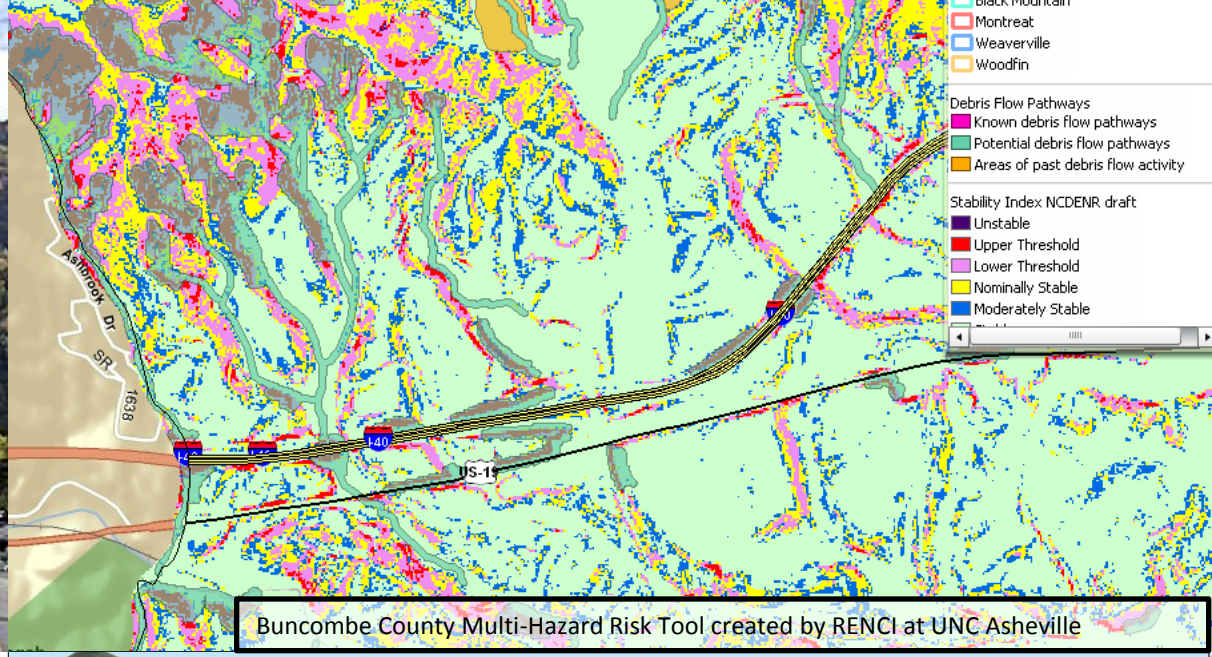


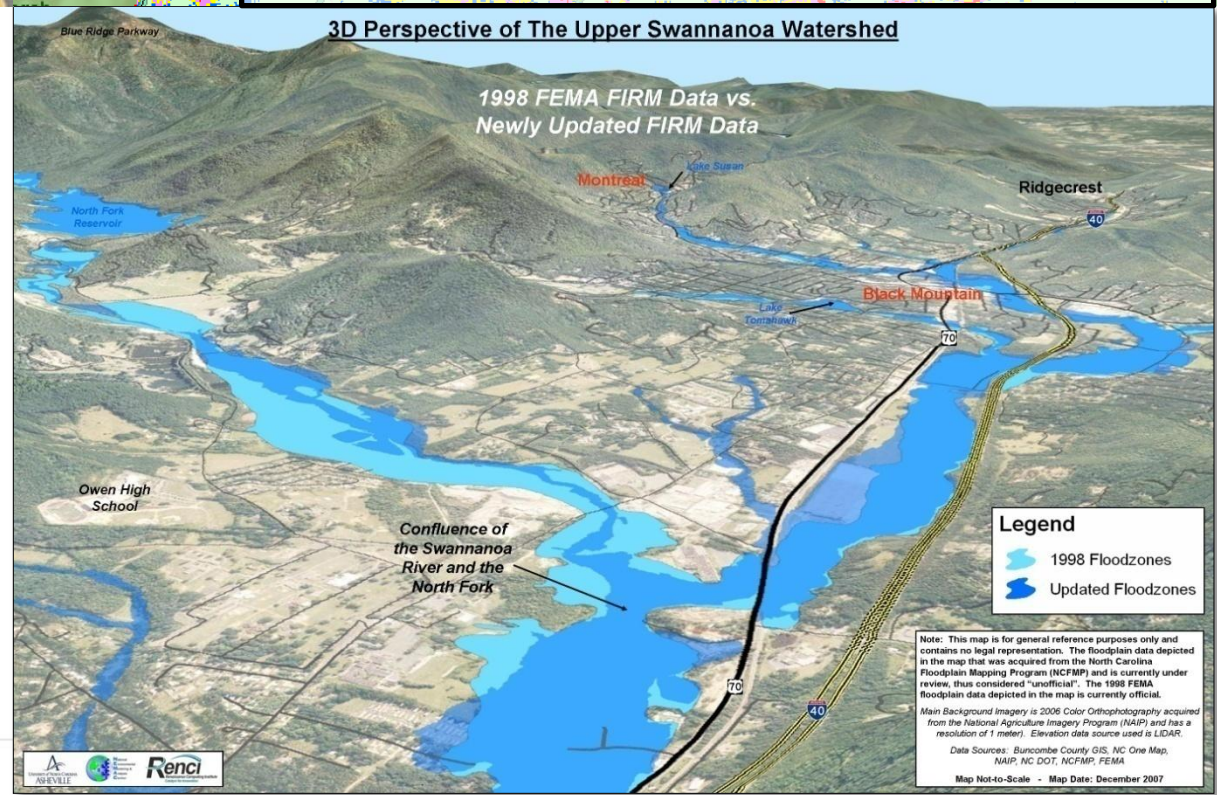
Photo courtesy of Asheville Citizen Times

Landslide on I-40 west of Asheville

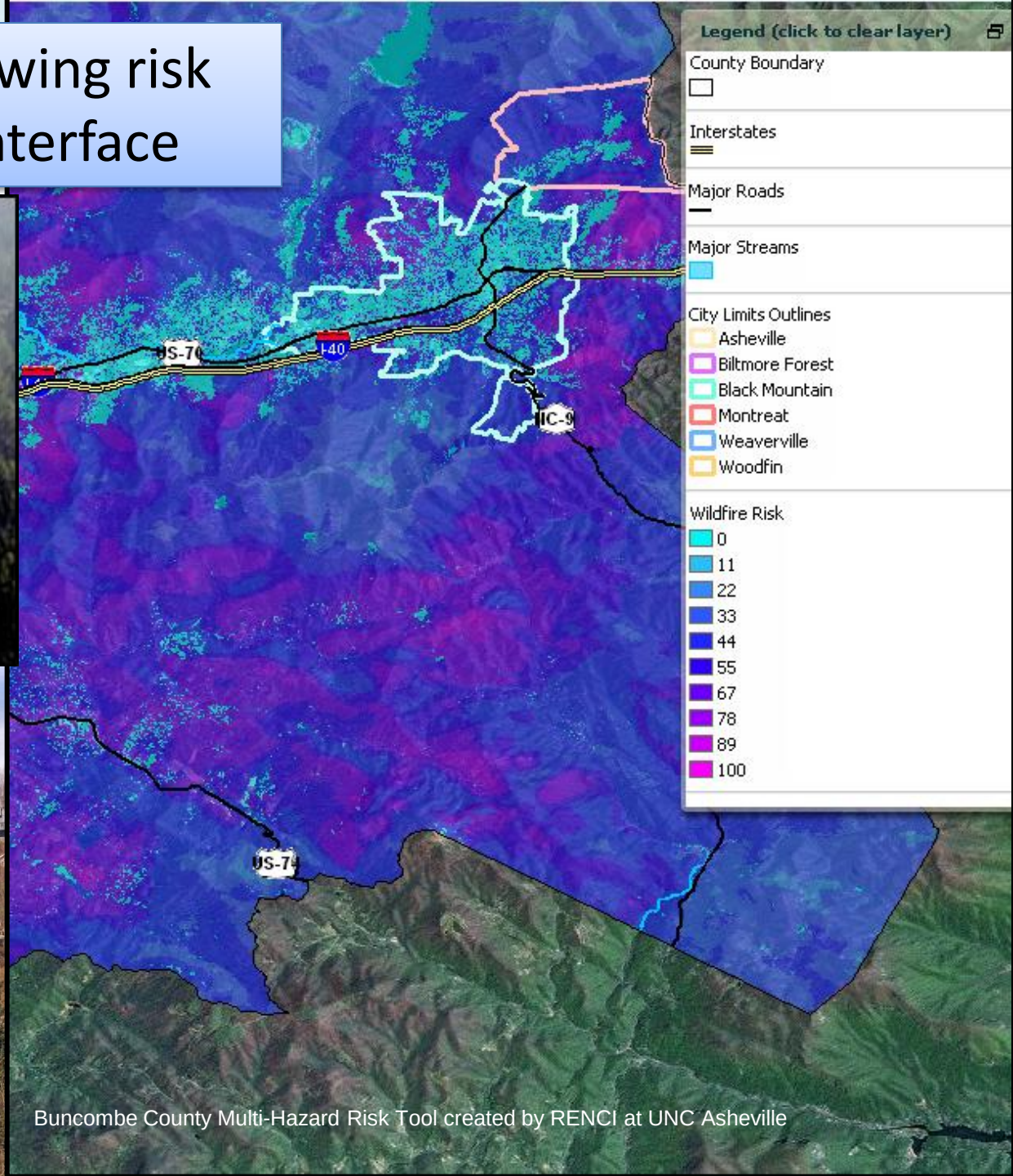


Buncombe County Multi-Hazard Risk Tool created by RENCI at UNC Asheville

Multi-Hazard Tool integrates floods, landslides, wildfire, winter storm and other risks



Wildfires and the growing risk at the urban/forest interface

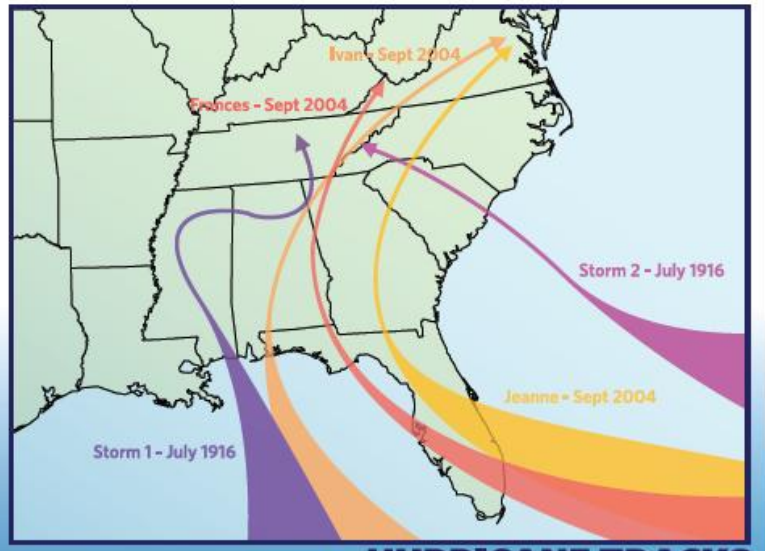


FLOODING & HURRICANES

Separated by 88 years, but the results were the same – major floods in Western North Carolina associated with the remnants of multiple hurricanes that arrived in rapid succession.

In 1916, two hurricanes dumped more than 20 inches of rain across the state (State record set at Altapass, Mitchell County – 22.22" in 24 hours). The rain was concentrated by orographic uplift over the Appalachian Mountains. After the second storm, all the rivers were in flood and there was major destruction. Recent clearing of forests in the area caused major landslides and the debris caught behind bridges and caused them to wash away. Almost all of the rail bridges were destroyed. Damage was estimated at $22 million (in 1916 dollars) and 80 people lost their lives.

In 2004, three hurricanes had a similar effect. Frances, Ivan and Jeanne flooded many communities, with major damage and loss of life in Canton, Waynesville and Asheville.



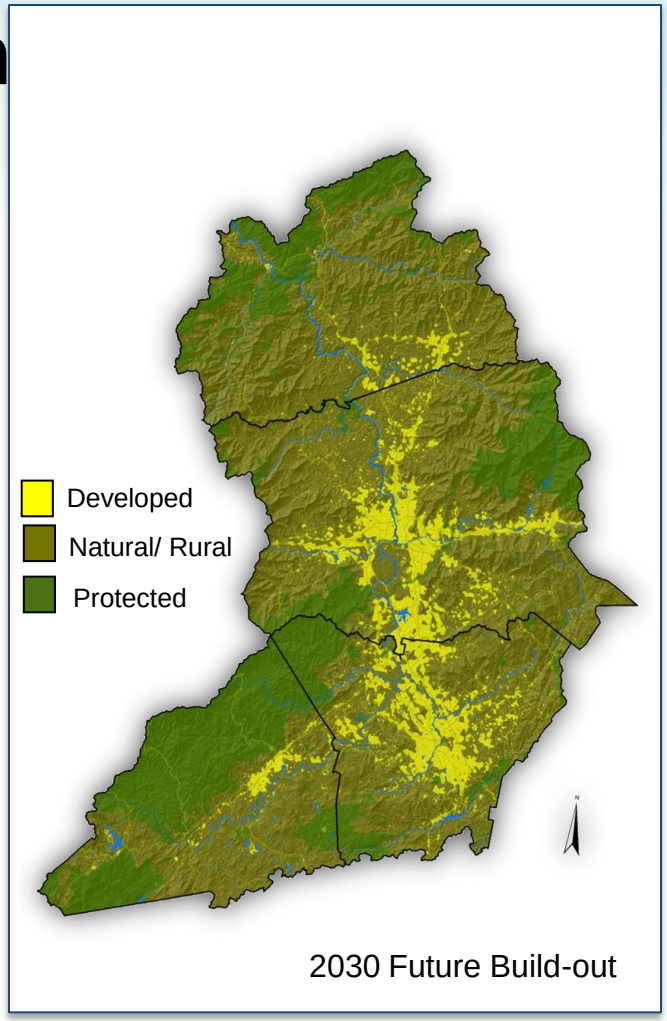
HURRICANE TRACKS

Tools are important , but communication of the issues through education and outreach are needed as well. This is a poster created for a local museum in the watershed.

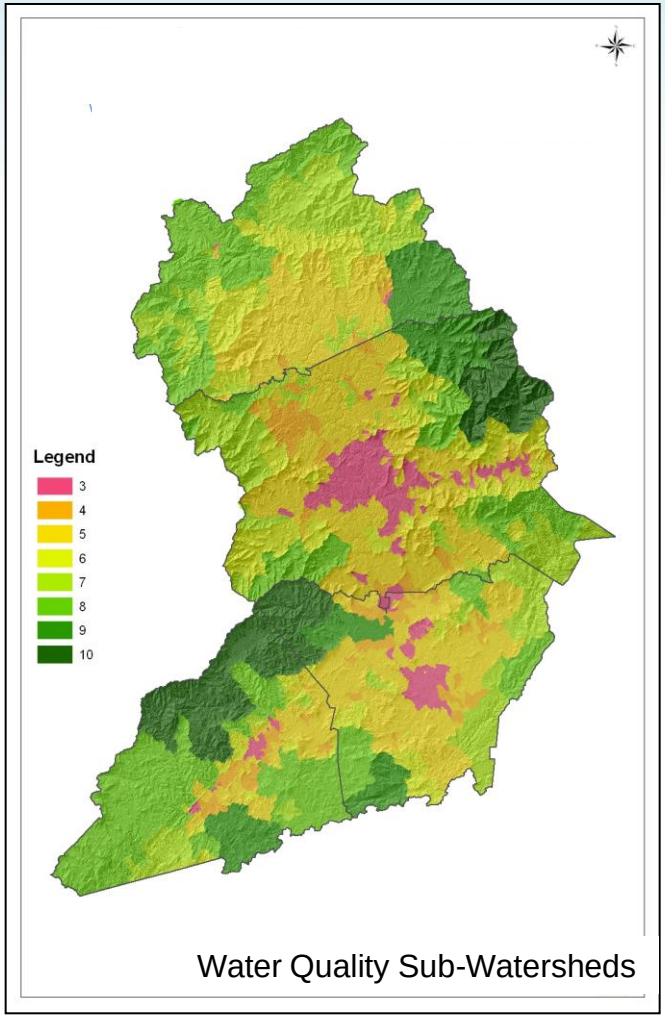
Southern Appalachian Man And the Biosphere SAMAB Climate Change Conference, 11/2009

- Value of Ecosystems Services
  - Water quality
  - Carbon sequestration
  - Flood storage
  - Local food supplies
- Natural Systems do not pay attention to jurisdictional boundaries
  - Must be managed on a regional scale
- Natural systems are less resilient to rapid climate change
- Land Use and Planning Issues
  - Planning process must integrate ecosystem services to create sustainable human communities

Ecosystem Services

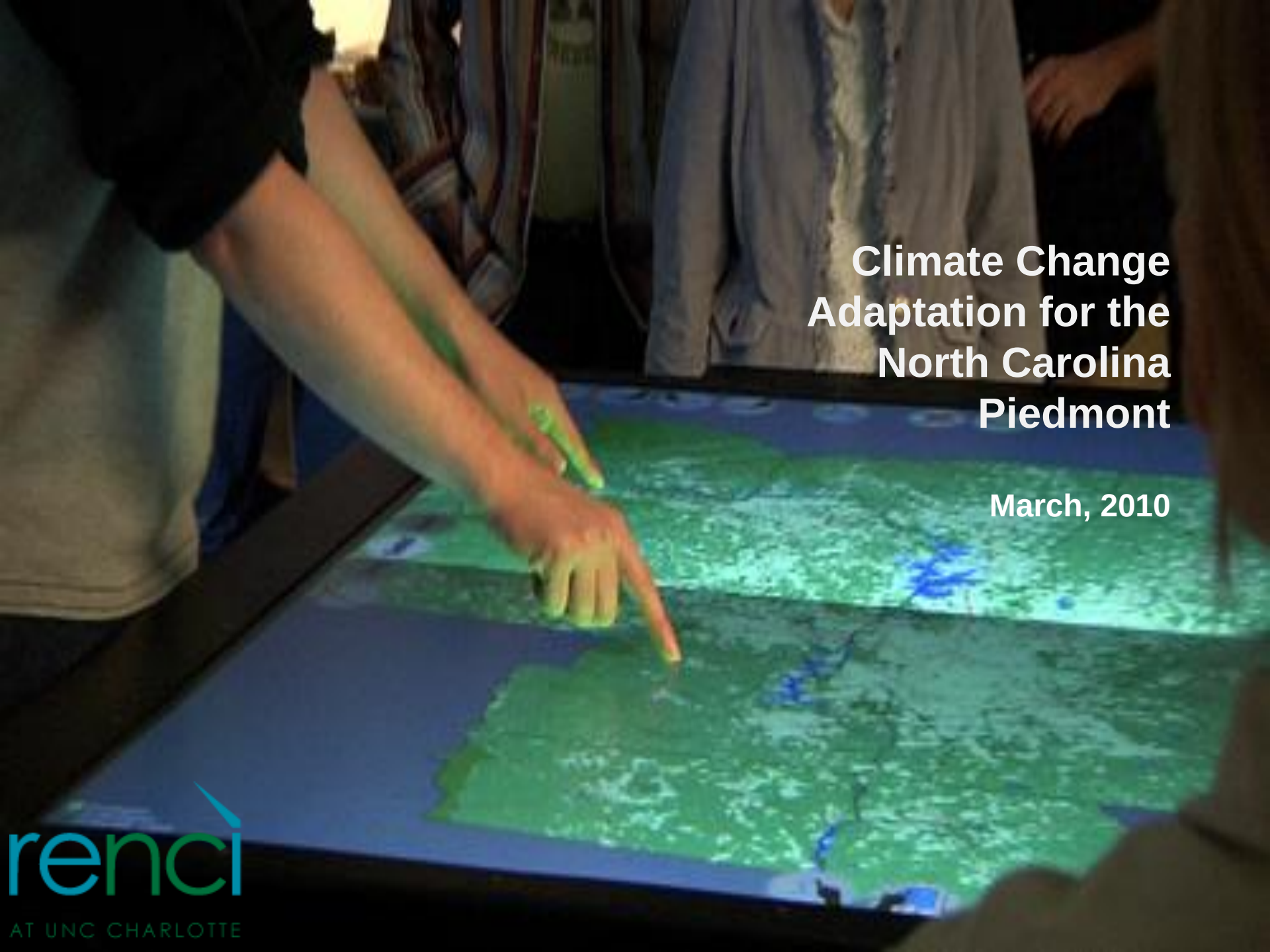


2030 Future Build-out



Water Quality Sub-Watersheds

- You can't manage the water without managing the land
- Regional planning tool tied to Green Infrastructure
- Sub-watersheds in the upper end of the basin and with little impervious surface hold greater value



Climate Change Adaptation for the North Carolina Piedmont

March, 2010

renci
AT UNC CHARLOTTE

Climate Change in North Carolina
Piedmont Region

Presentation Overview

- Key Impacts, Vulnerabilities & Adaptation
  - Precipitation Pattern-related
  - Temperature-related
- Other change-drivers
  - Urbanization & growth
  - Energy
- Piedmont Summary

Impacts of Climate Change

Piedmont Region

- Precipitation Pattern Changes
  - Decreased Storm Frequency
    - Drought / water supply
  - Increased Storm Intensity
    - Flooding
    - Wind damage
- Temperature Changes
  - Heat Island effects
  - Heat stress / heat illness
  - Agricultural crop migration / livestock impacts
  - Habitat, vegetation zone changes

Precipitation Pattern Changes

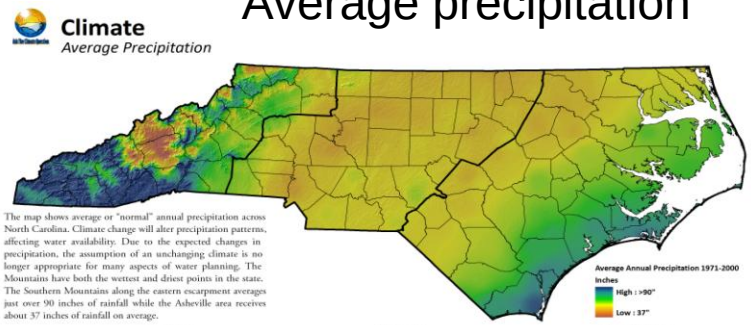
Piedmont Region

Increased Drought Risk

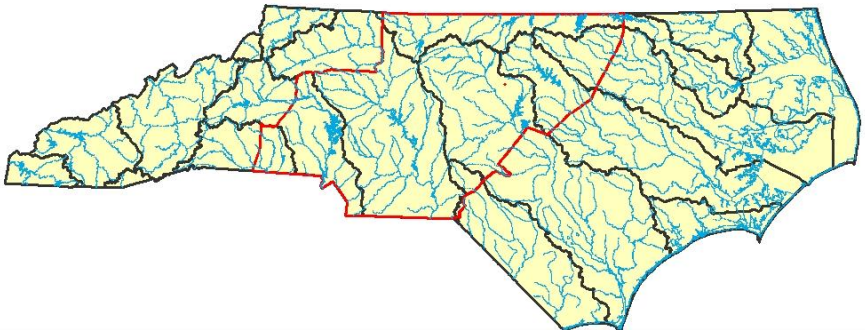
- Less frequent storms
- Low precipitation region
- Headwater reservoirs
- Small storage capacity

Inter-basin Transfers & Water Rights Battles

Average precipitation



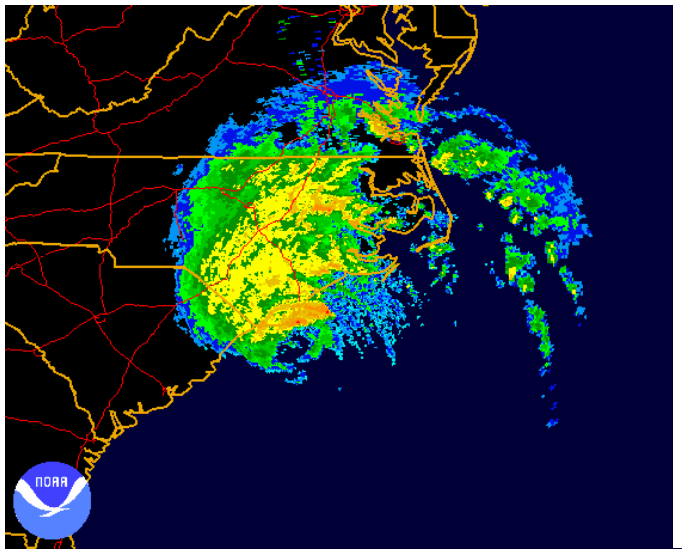
Basin Headwaters



Precipitation Pattern Changes

Piedmont Region

- More intense and damaging storms
  - Increased flood risk
    - Transportation impacts
  - Increased hurricane, tropical storm risk
    - Wind damage impacts



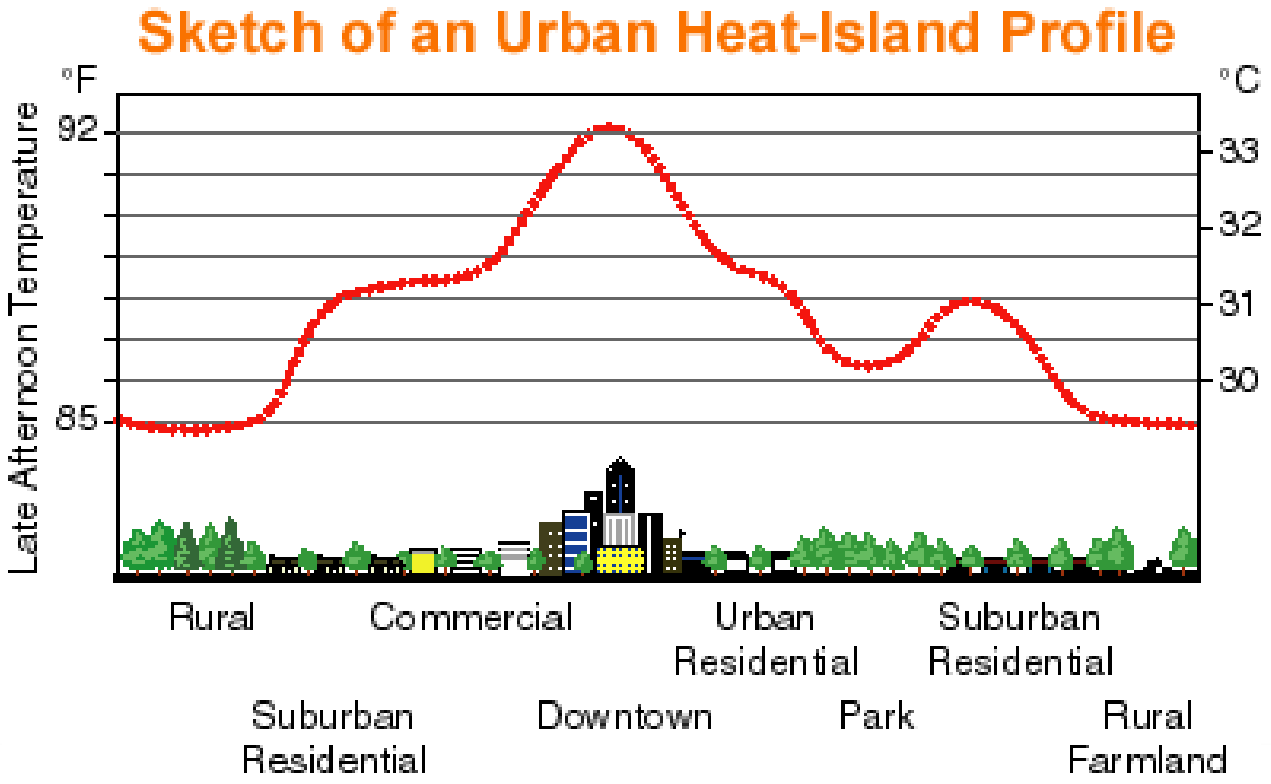
1999 Hurricane Floyd making landfall in North Carolina.

Courtesy of NOAA.

Temperature Changes

Piedmont Region

- Urban Heat Island Effect



Courtesy of the
Heat Island Group

Temperature Changes

Piedmont Region

Heat-related Illness

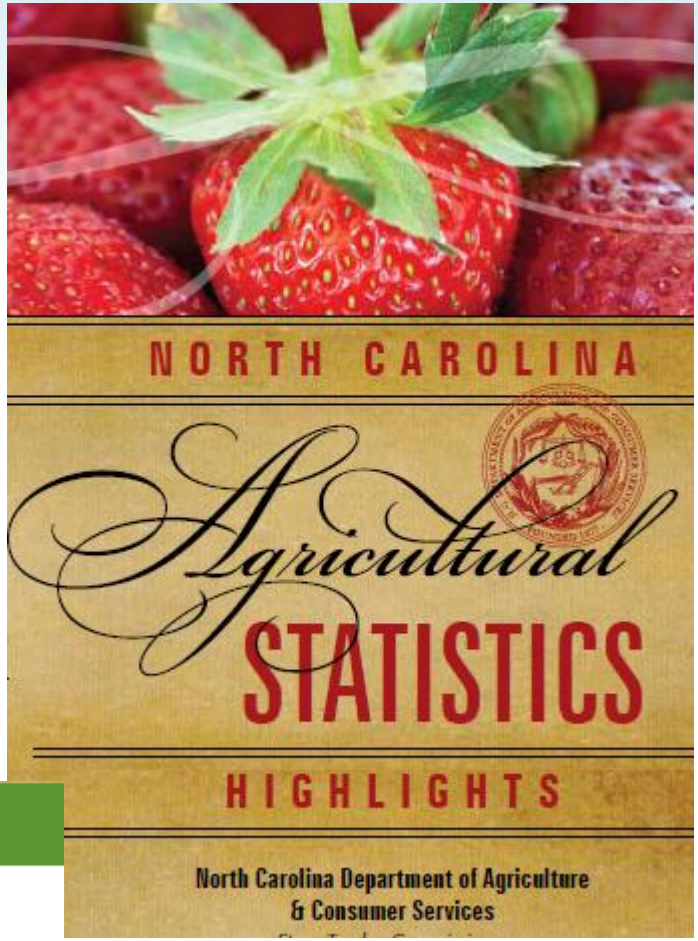
- Heat stress, heat stroke
  - Residents without air conditioning
  - Outdoor workers, athletes, children, bicyclists and pedestrians
- Respiratory / Unhealthy Air Quality Days
  - Increased ground-level ozone formation

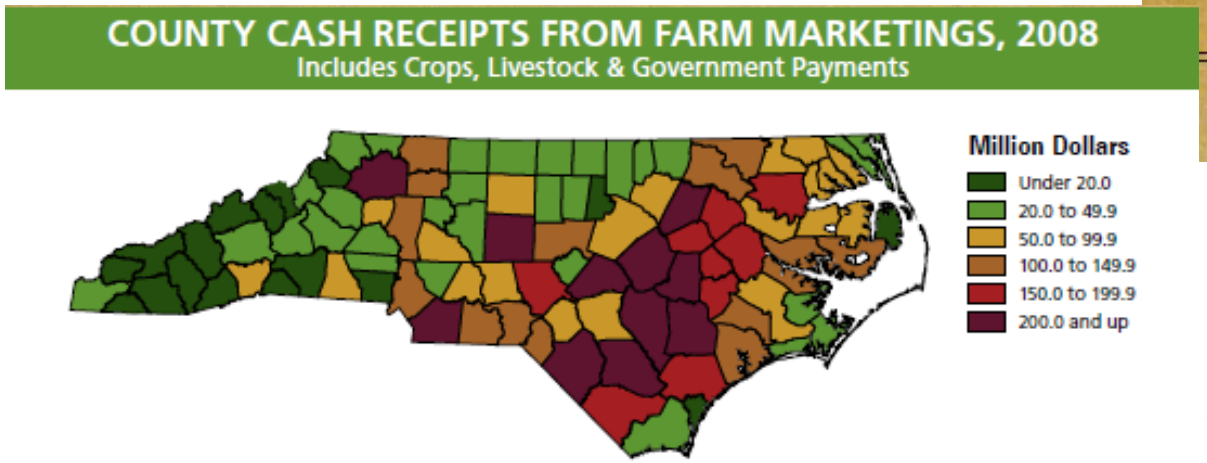
Temperature Changes

Piedmont Region

Agriculture

- Crop Migration
- Implications from drought and flood



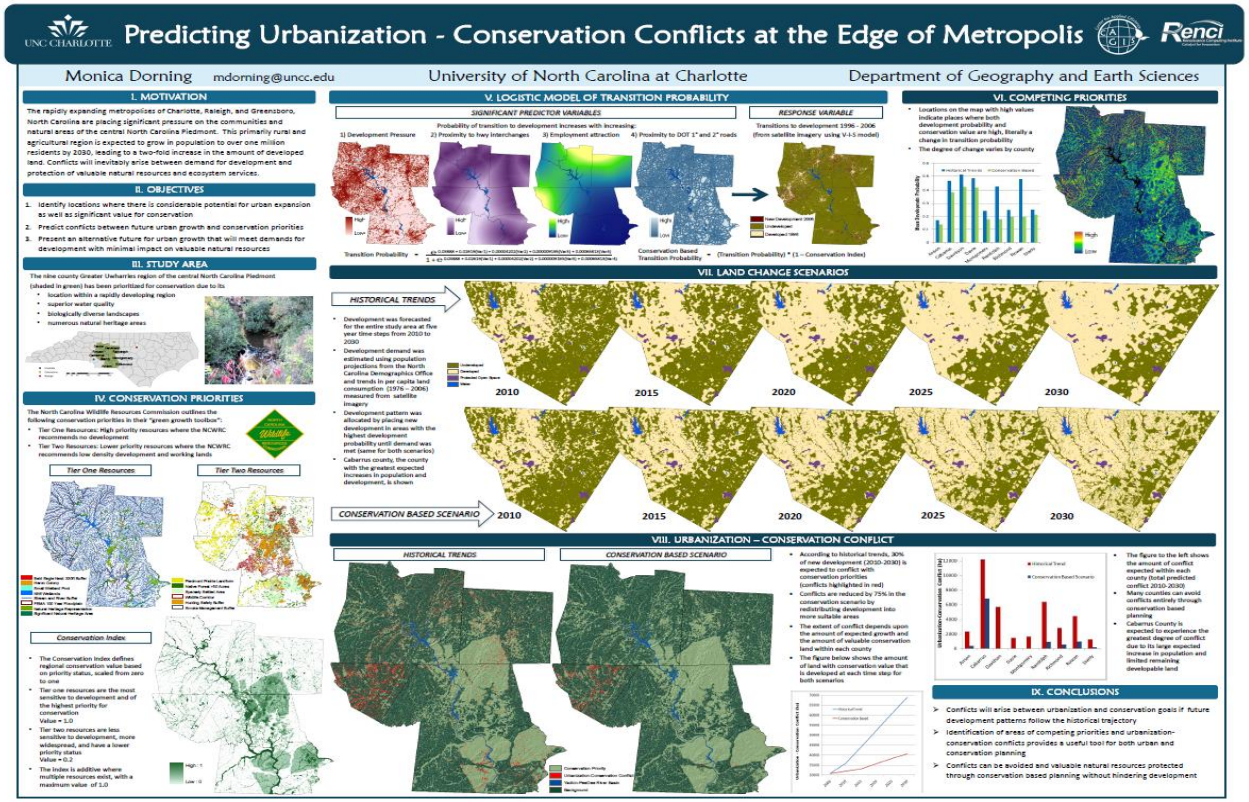


Temperature Changes

Piedmont Region

Habitat & Species Migration

- Conservation
- Development conflicts

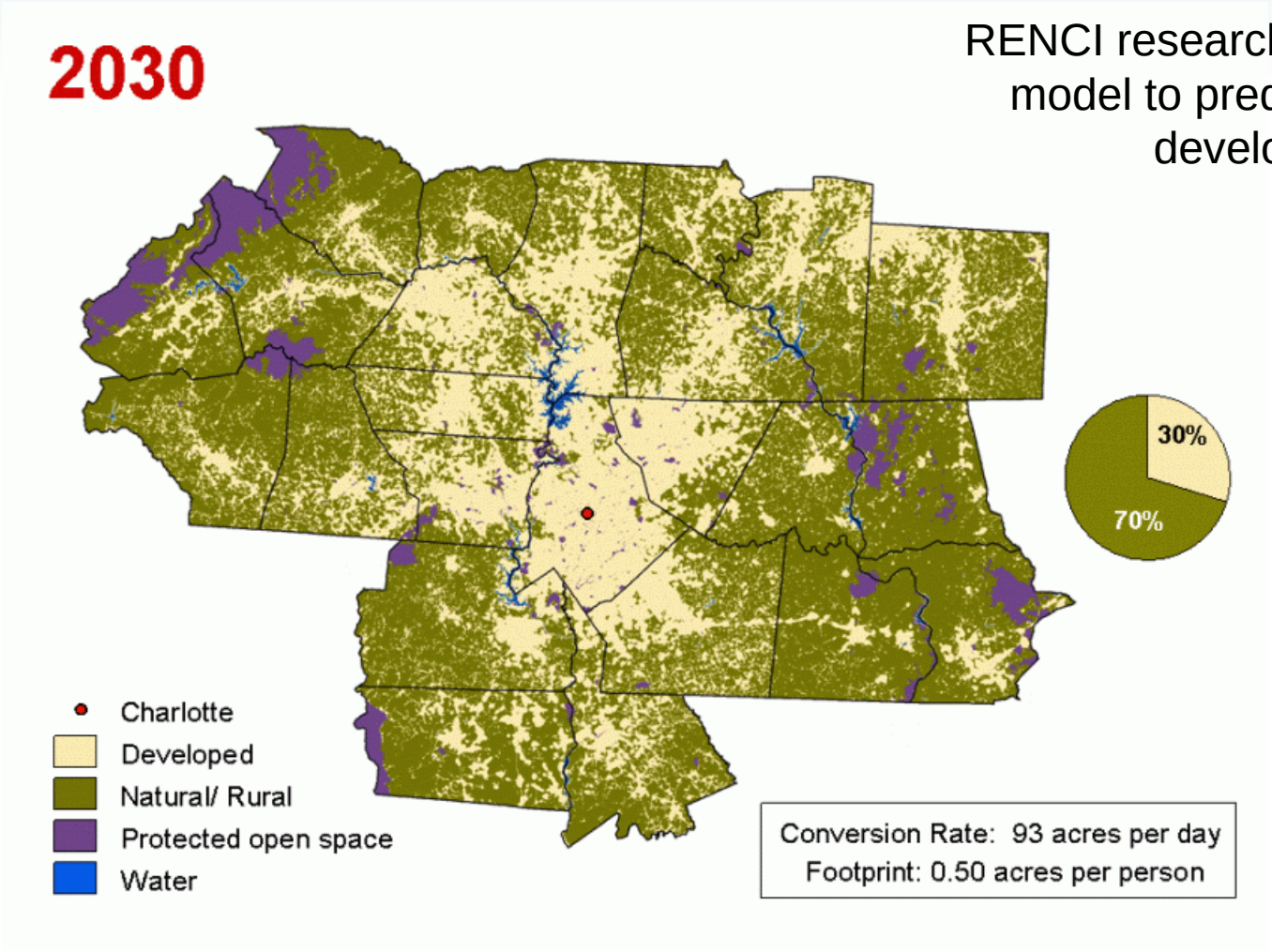


Other Change Drivers

Piedmont Region

- Urban Growth
  - Population Growth
  - Land Development
- Energy
  - Alternative Fuels

Urban Growth

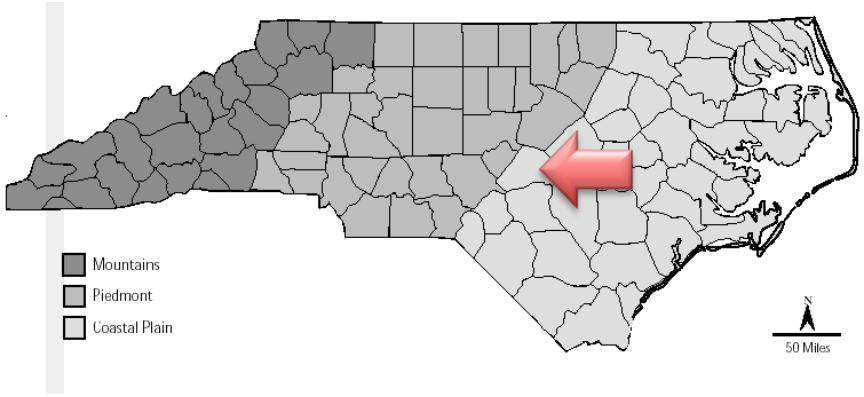


RENCI researchers created this model to predict future land development

Other Change Drivers

Piedmont Region

- Population growth
  - Existing in-migration patterns
  - Increased in-migration from coastal populations

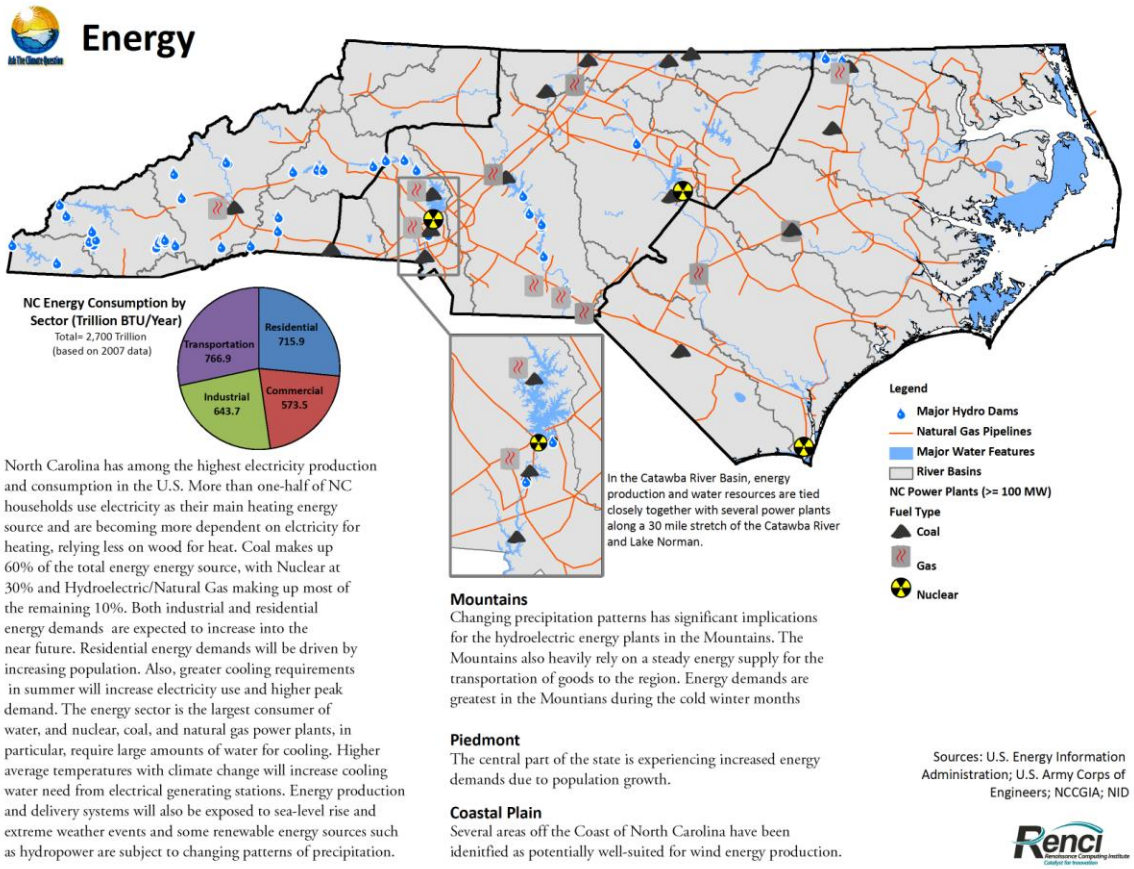


Other Change Drivers

Piedmont Region

Energy:

- Prevalence of Power Plants & Water Usage Issues

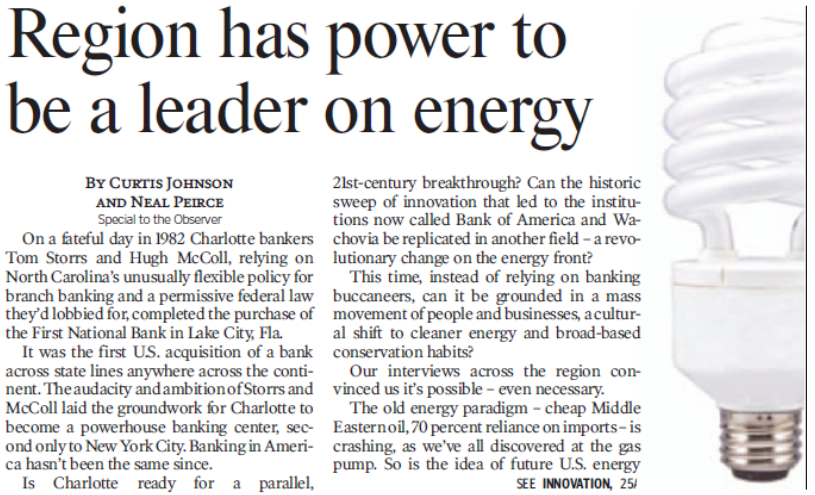


Other Change Drivers

Piedmont Region

Alternative Energy

- 2008 Citistates Report
  - Charlotte - major center for **nuclear energy engineering**
  - Hickory – **wind turbine** component production
  - Davidson County – $173 million **solar farm**
  - Concord – plant for **thin-film solar panel** production
  - EPIC – UNCC's Energy Production and Infrastructure Center



Region has power to be a leader on energy

By Curtis Johnson and Neal Peirce
Special to the Observer

On a fateful day in 1982 Charlotte bankers Tom Storrs and Hugh McColl, relying on North Carolina's unusually flexible policy for branch banking and a permissive federal law they'd lobbied for, completed the purchase of the First National Bank in Lake City, Fla.

It was the first U.S. acquisition of a bank across state lines anywhere across the continent. The audacity and ambition of Storrs and McColl laid the groundwork for Charlotte to become a powerhouse banking center, second only to New York City. Banking in America hasn't been the same since.

Is Charlotte ready for a parallel, 21st-century breakthrough? Can the historic sweep of innovation that led to the institutions now called Bank of America and Wachovia be replicated in another field – a revolutionary change on the energy front?

This time, instead of relying on banking buccaneers, can it be grounded in a mass movement of people and businesses, a cultural shift to cleaner energy and broad-based conservation habits?

Our interviews across the region convinced us it's possible – even necessary.

The old energy paradigm – cheap Middle Eastern oil, 70 percent reliance on imports – is crashing, as we've all discovered at the gas pump. So is the idea of future U.S. energy

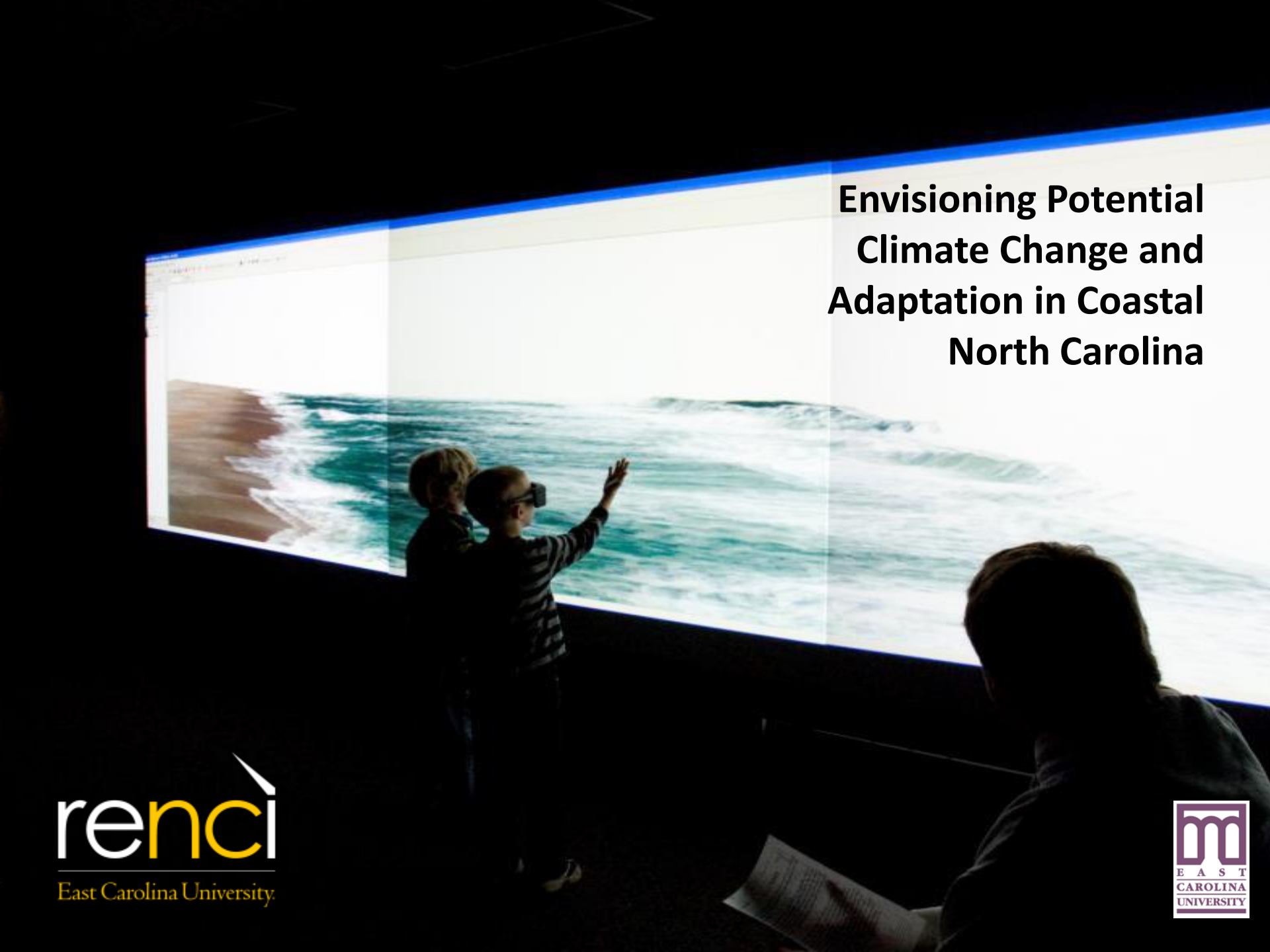
SEE INNOVATION, 25A

The Charlotte Observer, Sept. 21, 2008

Climate Change: Impacts, Vulnerabilities & Adaptation

Piedmont Region

Effect	Impact	Possible Adaptation Strategies	Vulnerable Populations
Precipitation Pattern Change	Decreased storm frequency - Drought risk	•Rainwater harvesting •Irrigation Efficiency	Low-Income Agricultural sector
	Increased storm intensity - Flood risk	•Relocation •Land Use Plan updates	Floodplain residents Low-Income
	Increased storm intensity - Hurricanes & tornados	•Building code updates •Climate Impact Analysis for new development	Elderly Youth Low-Income
Temperature Increase	Heat island effects Increased risk of heat stress	•Air conditioning funding programs •Tree canopy ordinances/requirements	Elderly Youth Low-Income Urban residents
	Agricultural crop migration	•Crop suitability studies •Farmer assistance programs	Agriculture Sector Business Community
	Habitat and vegetation zone migration	•Vulnerable species Identification	



Envisioning Potential Climate Change and Adaptation in Coastal North Carolina

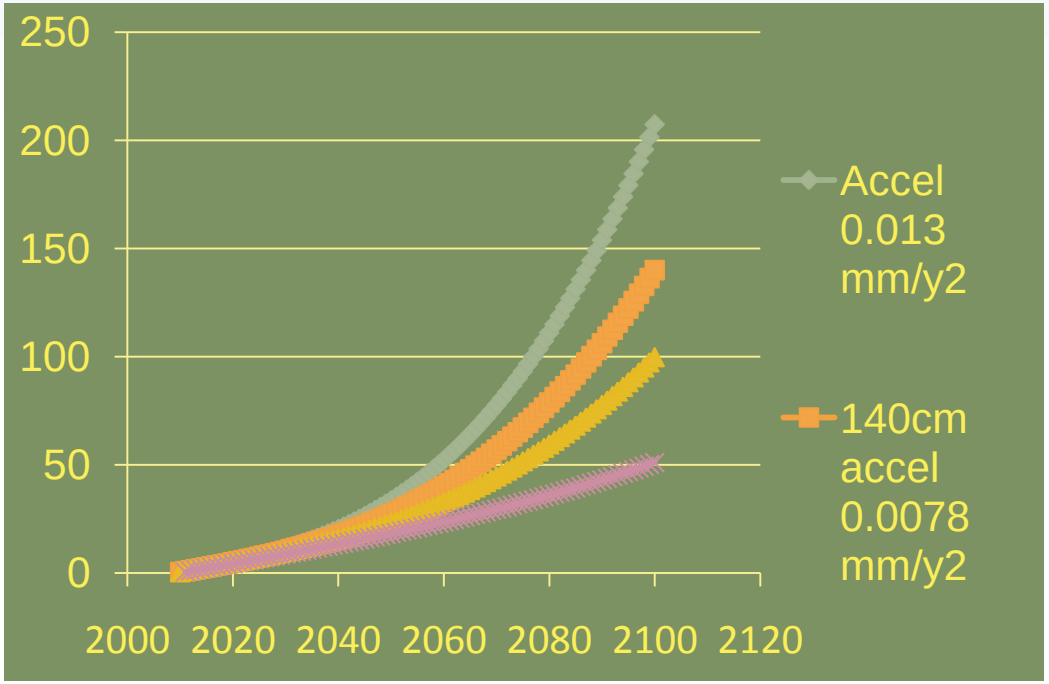
renci
East Carolina University

East Carolina University

Resources at Risk

- Natural Resources
  - 325 miles of barrier beaches
  - 20 inlets
  - 5000+ miles of estuarine shoreline
- Residents
  - 865,000 people today
  - Tourism, agriculture, forestry, ports, and fisheries
- Public Lands, Ecosystems, and Infrastructure
- Cultural Heritage

Proactive management strategies that increase adaptive capacity of ecosystems are needed for accelerating SLR.

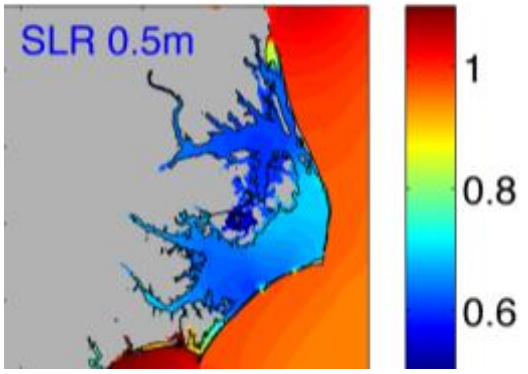


NC-Specific Sea-level Rise (Kemp et al. 2009)

Courtesy Brian Boutin, TNC

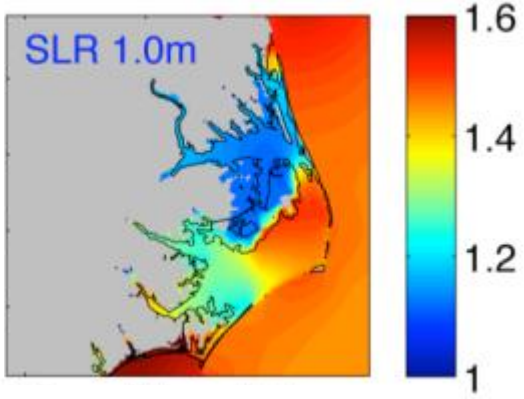
Sea-Level Rise

Higher energy currents, waves, and storm surges.



SLR outpacing vegetation retreat.

Barrier island breaching will induce tides in the sounds.



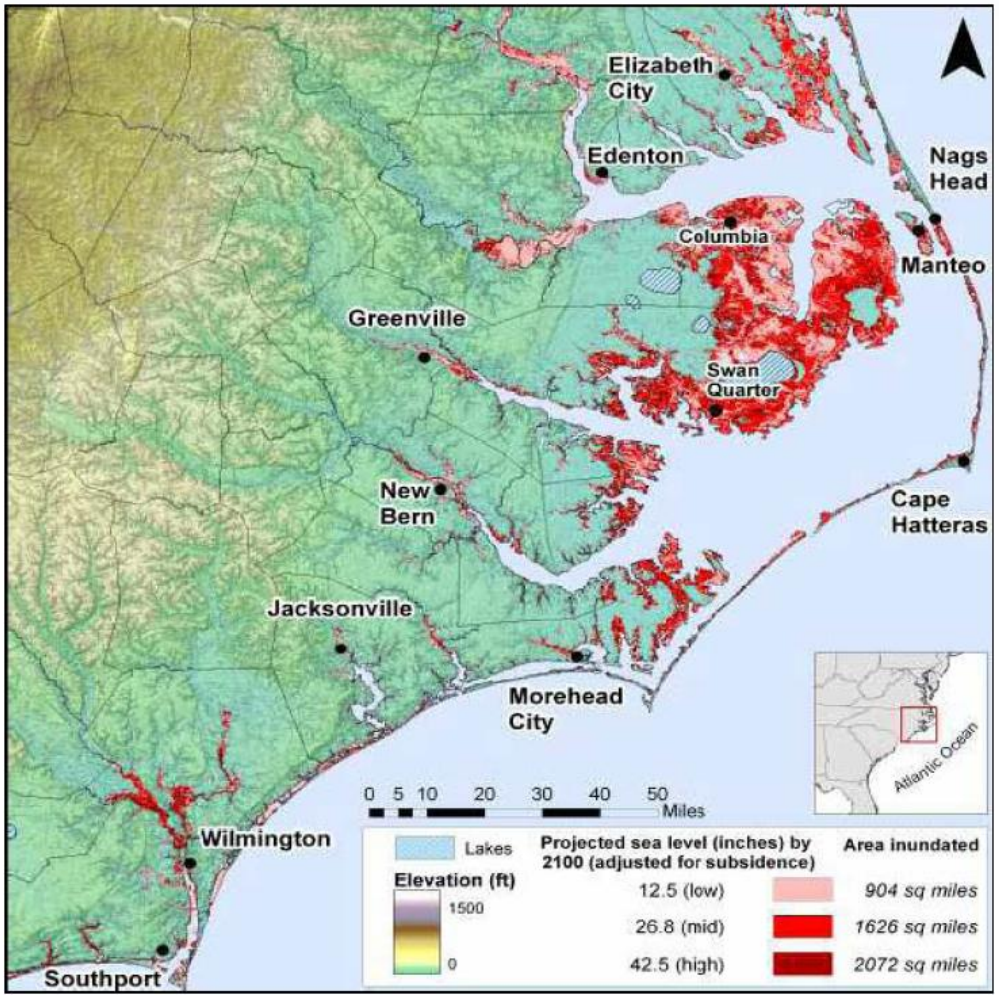
Courtesy Rick Luettich and Tom Shay, UNC-IMS

Increasing Rate of SLR Will Likely Outpace Vegetation Retreat, Collapsing Ecosystems

- **Adaptation/management strategy**: Restore brackish marsh vegetation along shoreline to maintain natural buffer.

Courtesy Brian Boutin, TNC

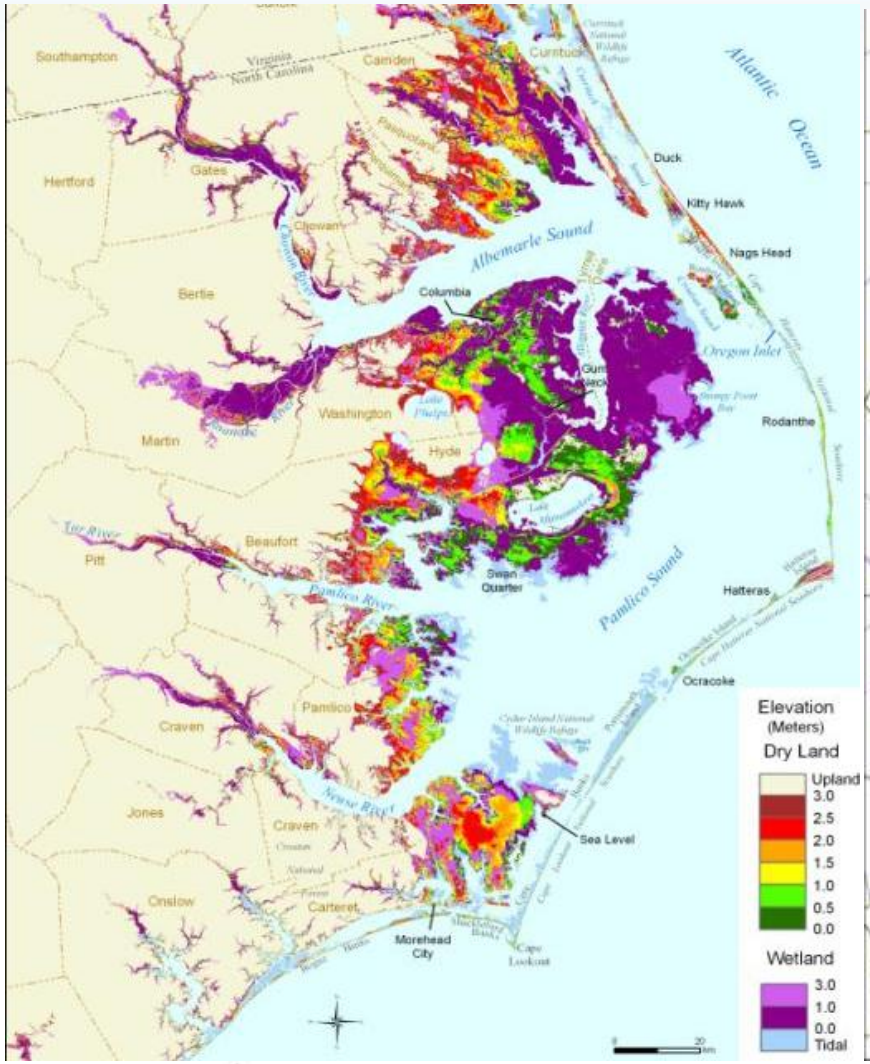
SLRise Property Loss

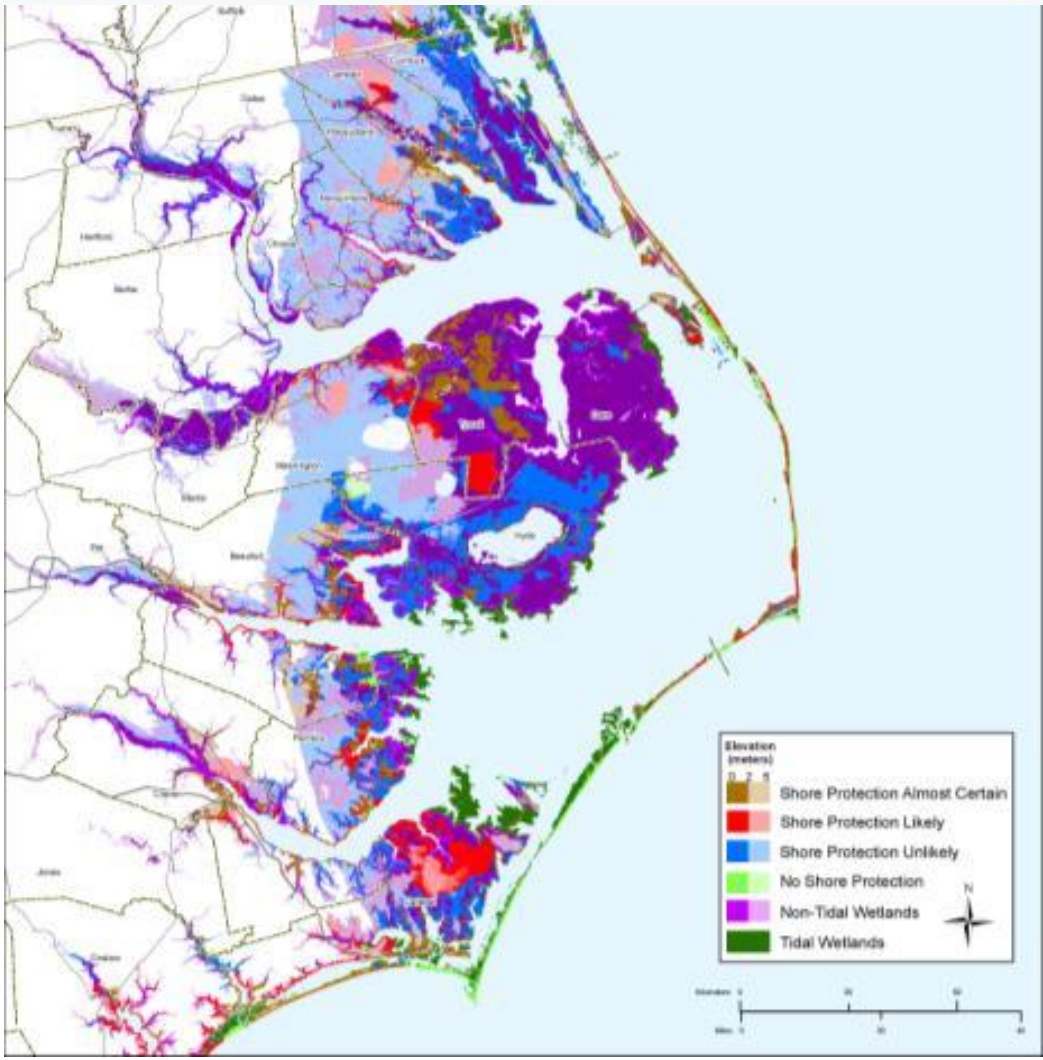


Bin, Dumas, Poulter, and Whitehead (for National Commission on Energy Policy)
http://econ.appstate.edu/climate

Vulnerability

Resistance

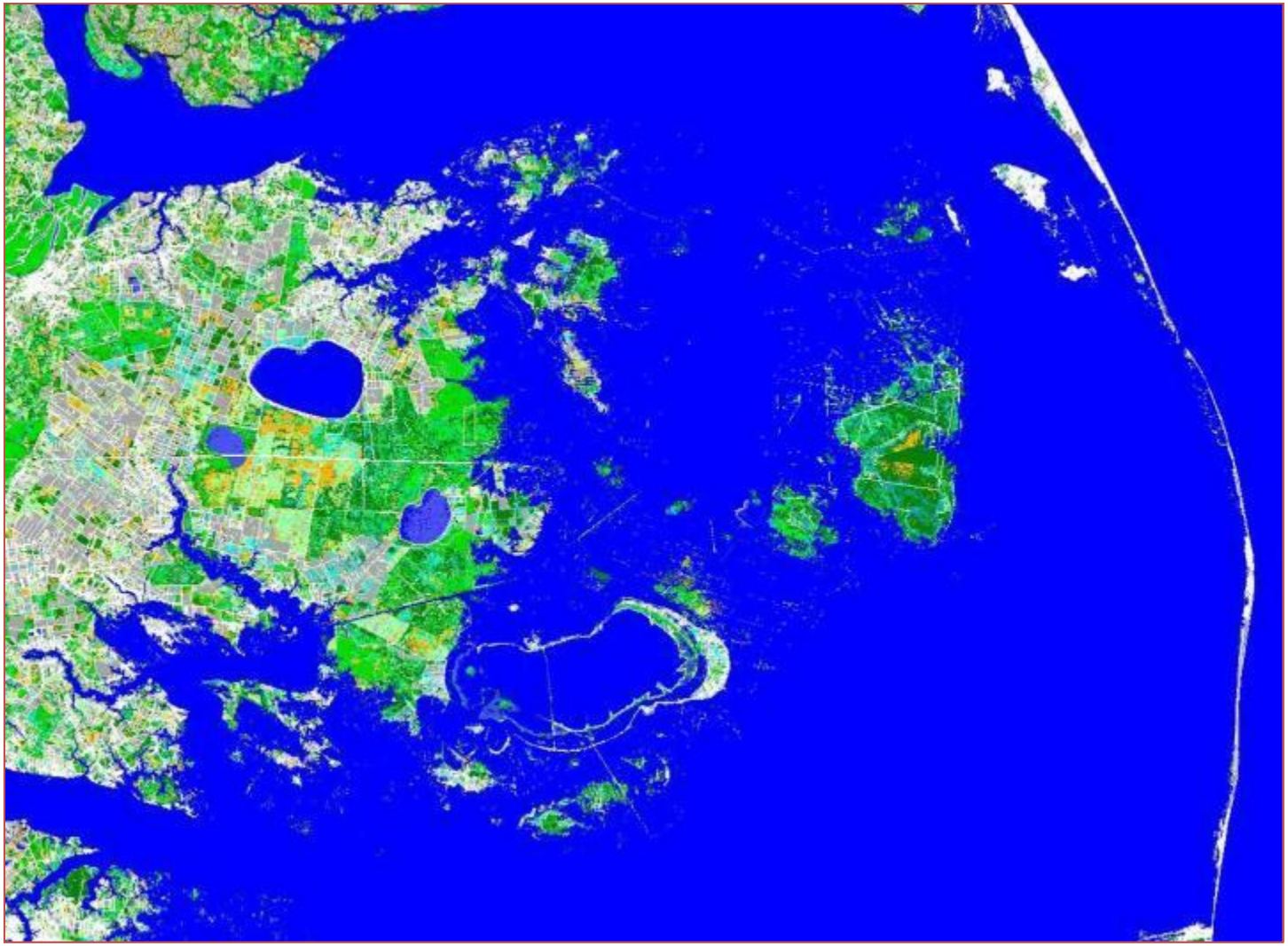




Titus, J.G. and J. Wang. 2008. *Maps of Lands Close to Sea Level along the Middle Atlantic Coast of the United States*. US EPA.

SLRise in the Albemarle-Pamlico

- RSLR in the 20th century: 3.0–3.3 mm/yr*
- FEMA-funded NCEM SLR Risk Mgt. Study underway



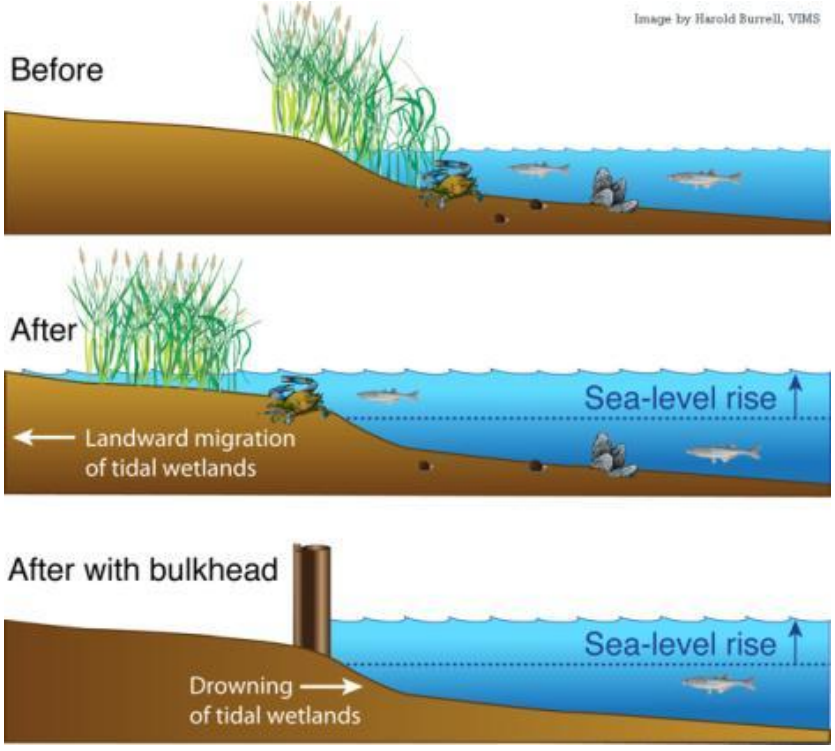
- *Kemp et al. 2009
- Map courtesy Brian Boutin (TNC), Ben Poulter

Coastal Storms

- Potential increase in frequency and intensity
- Category 4 hurricanes may reach NC
- Extremes in precipitation
- Drought severity

Land Loss, Shoreline and Riparian Buffers

Bulkheading and other structures in the public domain inhibit landward habitat migration, endangering aquatic living resources



Harold Burrell, Va. Inst. Marine Sci.

***Adaptation/management strategy**: Living shorelines.*

Oyster restoration

- **Adaptation/management strategy**: oyster reef restoration along high energy shorelines.

Salt Intrusion Into Extensive Ditch Networks

- Salt-poisoning of interior wetland vegetation.
- Rapid decomposition of peat soils by sulfate-reducing bacteria.
  - **Locally**: subsidence and increased inundation
  - **Globally**: release of previously sequestered carbon as carbon dioxide and methane.

*Hackney, C. T., and G. F. Yelverton. 1990. Effects of human activities and sea level rise on wetland ecosystems in the Cape Fear River Estuary, North Carolina, U.S.A. Pgs 55-61 in WETLAND ECOLOGY AND MANAGEMENT: Case Studies, D. F. Whigham, R. F. Good and Y. Kvet, eds. Kluwer Academic Publishers, Amsterdam, The Netherlands.

Courtesy Brian Boutin, TNC

Restoring Natural Hydrologic Regimes

- **Adaptation/management strategy**:
- Installation of water control structures equipped with flashboard risers and tide gates at strategic locations.
- Preserving carbon reservoir in peatlands also forestalls additional climate change

Courtesy Brian Boutin, TNC

Coastal Agriculture and Forestry

- Hurricane frequency and intensity increase agricultural damage
- Timber damage will increase

  ~ $1B damage per storm event increase Cat 2 to Cat 3

- Additional potential increases in drought, pathogens, and wildfire

Storm Category	NC Statewide Totals (2004 $'s)
Tropical Storm	$53,695,368
Category 1	$32,878,317
Category 2	$208,558,508
Category 3	$837,822,329

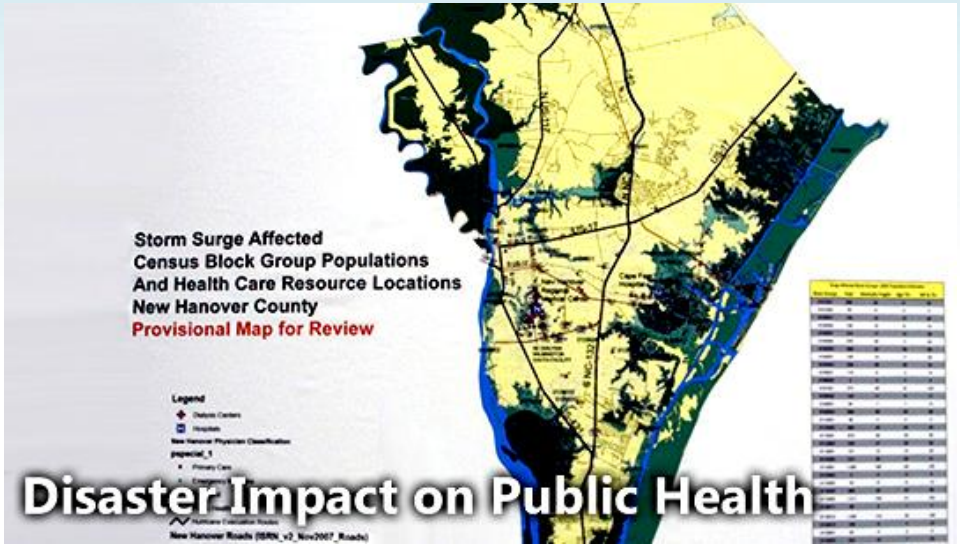
1996-2006 Bin et al. (2008)

Climate Change and Coastal Tourism

- Climate-induced SLRise will reduce beaches
- Selected fishing access
- Uncertain impacts on fisheries, inshore, estuaries
- Potential future resource conflicts

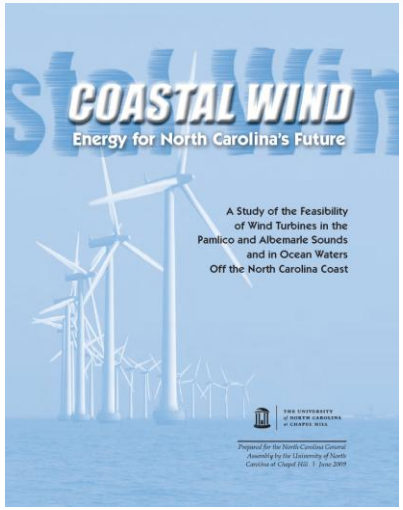
Public Health

- Heat waves
- Air and water quality stressors
- Surface water resources and groundwater salinization
- Demographic shifts and social vulnerability
- Invasive pathogens
- Emerging infectious diseases



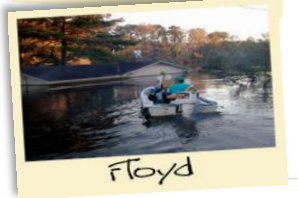
Coastal Energy Development

- Fossil fuels
- Wind farms
- Potential biofuels, tides, currents, & waves
- Value of carbon reservoirs and ecosystem services



"Those who forget the past are condemned to repeat it."

1880 1900 1920 1940 1960 1970 1980 1990 2000 2010



Impact Maps Images Compare

North Carolina is vulnerable to destructive hurricanes and storms. Citizens and visitors must be prepared for this reality.

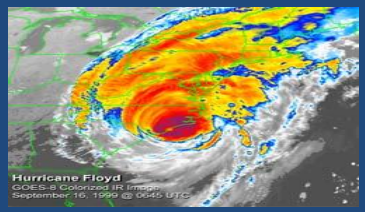
Storms to Life aims to raise awareness of North Carolina's storm history and the risks of coastal life.

Visitors to the **Storms to Life** website will experience a multimedia history of the hurricanes and storms that have hit North Carolina over the last few centuries. Features include…

- Interactive maps and models
- Photographs
- Videos
- Graphs and tables
- Narratives and interviews

Visitors will also be able to compare storms and learn about the impact and science behind these events.


THE NEWS&OBSERVER
The onslaught begins
Floyd bears down on huge swath of N.C.
Triangle at the ready



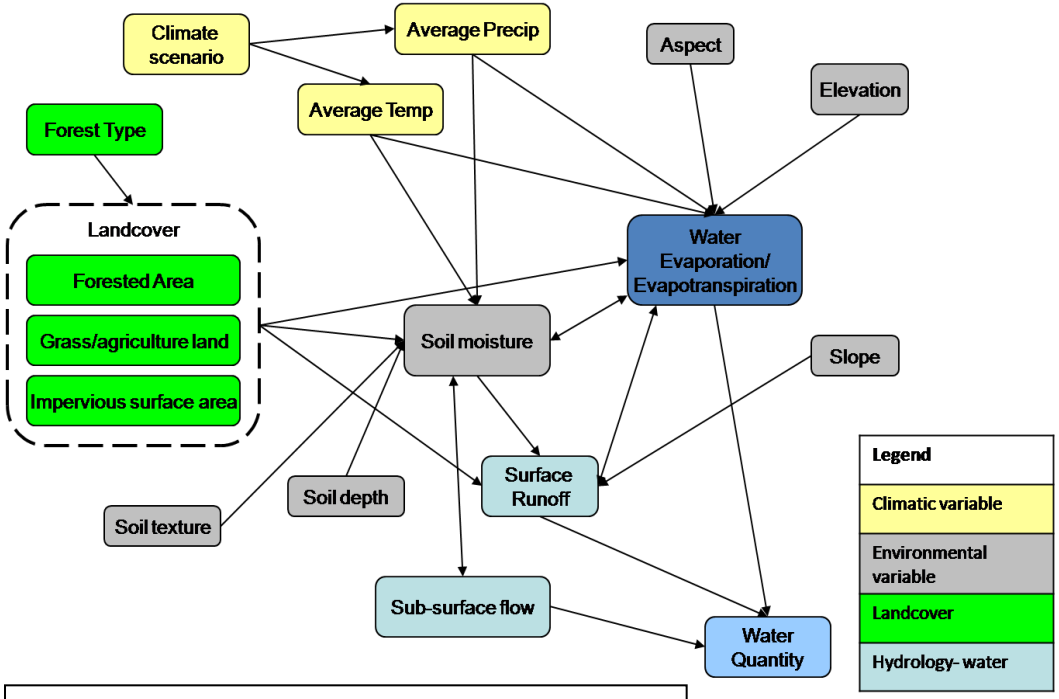
www.ecu.edu/renci/stormstolife

How to implement?

- Act locally, but tie actions to regional, state, and global impacts
  - Locally *adapt* to globally-forced change
  - Locally *mitigate* to forestall worsening climate scenarios
- Place-based vulnerability
  - Impact of landslides on WNC transportation and economy
  - Coastal sea-level rise impacts: vulnerable population, resources, tourism, agriculture, and transportation
- Integrate with other drivers, with a focus on VALUE
- “No regrets” approach
- Economics will be the key

Planning Tools

- Combine data with different community value drivers
- Adaptation plans will have metrics to see where we can improve
- Nurture innovative "Sustainability networks" and virtual organizations engaging practitioners, scientists, and decision-makers



Eastern Forest Environmental Threat Center
CRAFT Decision Support Tool

Solving the climate change adaptation puzzle will require:

- Understanding region-specific climate change impacts
- Adaptation strategies aligned with regional impacts
- Cross-disciplinary collaboration

"You will have a chance to practice all three in this afternoon's sessions after lunch!"

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